

## ***SECTION 12 – TEMPERATURE***

### **SUMMARY**

As a result of the 1998-1999 SWQB/NMED monitoring effort in the Jemez River Basin, several exceedances of New Mexico water quality standards for temperature were documented on Redondo Creek, San Antonio Creek, Rio Cebolla, Rio de las Vacas, and Rito Peñas Negras. Figures 5.B.1 and 5.B.2 in Section 5 show the land use/cover and land ownership percentages for the segment of Redondo Creek listed for this constituent (Redondo Creek from its mouth on Sulphur Creek to the headwaters). Figures 5.C.1, 5.C.2, 5.F.1, 5.F.2, 5.G.1, 5.G.2, 5.I.1 and 5.I.2 also in Section 5, show the land use/cover and land ownership percentages for the segments of San Antonio Creek (from its confluence with East Fork of the Jemez River to the headwaters), Rio Cebolla (2) (from its inflow to Fenton Lake to the headwaters), Rio de las Vacas (from its confluence with Rio Cebolla to Rito de las Palomas), and Rito Peñas Negras (from its mouth on Rio de las Vacas to the headwaters), respectively. Detailed descriptions of these stream segments can be found in subsections B, C, F, G, and I, Section 5 of this document.

Recording thermographs were deployed in mid-July, 1998, at 13 locations in the Jemez River Basin and were retrieved that same year, in late September. These were set to measure and record water temperatures every hour. The thermograph identification codes and location descriptions are given in the Thermograph Summary Table (Table 4). Thermograph locations are shown with the sampling stations in Figure 4 of this document. These locations and descriptions of the data are discussed in the latter part of this section.

### **ENDPOINT IDENTIFICATION**

#### **Target Loading Capacity**

Overall, the target values for this TMDL will be determined based on 1) the presence of numeric criteria, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document target values for temperature are based on numeric criteria. This TMDL is consistent with the State's antidegradation policy.

The New Mexico WQCC has adopted numeric water quality standards for temperature to protect the designated use of HQCWF. These water quality standards have been set at a level to protect cold-water aquatic life such as trout. The HQCWF use designation requires that a stream reach must have water quality, stream bed characteristics, and other attributes of habitat sufficient to protect and maintain a propagating coldwater fishery (i.e., a population of reproducing salmonids). The primary standard leading to an assessment of use impairment is the numeric criterion for temperature of 20 °C (68°F)<sup>1</sup>.

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<sup>1</sup> New Mexico Water Quality Control Commission, *State of New Mexico: Standards for Interstate and Intrastate Surface Waters (20.6.4 NMAC)*, 20.6.4.900 NMAC Standards Applicable to Attainable or Designated Uses Unless Otherwise Specified in 20.6.4.101 Through 20.6.4.899 NMAC.

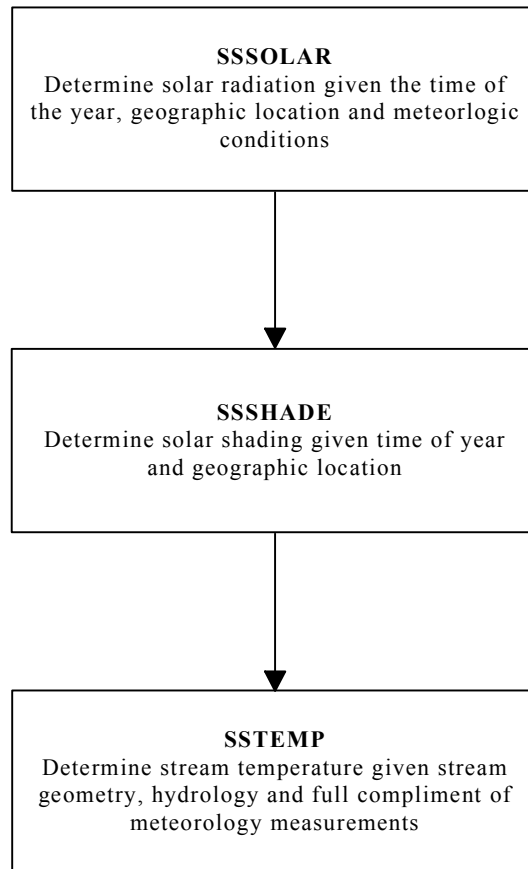
## Load Allocations

### **The Stream Segment and Stream Network Temperature Models<sup>2</sup>**

Water temperature can be expressed as heat energy per unit volume. The Stream Segment Temperature Models (SSTEMP) provide an estimate of heat energy per unit volume expressed in Joules (the absolute meter kilogram-second unit of work or energy equal to  $10^7$  ergs or approximately 0.7375 foot pounds) per meter squared per second ( $J/M^2/S$ ) and Langleys (a unit of solar radiation equivalent to one gram calorie per square centimeter of irradiated surface) per day.

The SSTEMP programs are currently divided into three related but separable components or submodels. Though technically the programs can be run in any order, for our purposes, we will conceptualize them in a physically based order shown in the flowchart below (Figure 12-1).

**FIGURE 12-1 MODEL COMPONENTS**



<sup>2</sup>

US Geological Survey, Biological Resource Division, Midcontinent Ecological Science Center, River Systems Management Section, Fort Collins, CO, 1997. *The Stream Segment and Stream Temperature Models, Version 1.0*, pp. 35-50

## Determining the Local Solar Radiation (SSSOLAR)<sup>3</sup>

To parameterize the model, follow the procedure outlined below:

**Beginning Month and Day** – Enter the number of the month and day which start the time period of interest.

**Ending Month and Day** – Enter the number of the month and day which end the time period of interest.

**Number of Days** – The number of days is a factor which tells the program when and how often to sample during the period. If the results are for a single day only, use one day. For periods between a day and a month, 2 days is sufficient. Time periods greater than a month are not recommended.

**Latitude (degrees and minutes)** – Latitude refers to the position of the stream segment on the earth's surface relative to the equator. It may be read from any standard topographic map. You should enter both degrees and minutes in the spaces provided.

**Elevation** – Read the mean elevation off of the topographic map.

**Air Temperature (°F)** – Mean daily air temperature representative of the time period modeled.

**Relative Humidity (percent)** – Mean daily relative humidity representative of the time period modeled.

**Possible Sun (percent)** – This variable is an indirect measure of cloud cover. Ten percent cloud cover is 90% possible sun. Estimates are available from the weather service or can be directly measured.

**Dust Coefficient** – This dimensionless value represents the amount of dust in the air. Representative values are:

Winter	-	6 to 13
Spring	-	5 to 13
Summer	-	3 to 10
Fall	-	4 to 11

If all other variables are known, the dust coefficient may be calibrated by using known ground-level solar radiation data. For the purposes of this model, an intermediate value is sufficient; the model is not a very sensitive variable. For example, when modeling summer conditions, entering 6.5 will suffice.

**Ground Reflectivity (percent)** – The ground reflectivity is a measure of the amount of short wave radiation reflected from the earth back into the atmosphere, and is a function of vegetative cover, snow cover or water. Representative values are:

Meadows and fields	14
Leaf and needle forest	5 to 20
Dark, extended mixed forest	4 to 5

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<sup>3</sup>

US Geological Survey, Biological Resource Division, Midcontinent Ecological Science Center, River Systems Management Section, Fort Collins, CO, 1997. *The Stream Segment and Stream Temperature Models, Version 1.0*, pp. 37-39

Heath	10
Flat ground, grass covered	15 to 33
Flat ground, rock	12 to 15
Flat ground, tilled soil	15 to 30
Sand	10 to 20
Vegetation, early summer	19
Vegetation, late summer	29
Fresh snow	80 to 90
Old snow	60 to 80
Melting snow	40 to 60
Ice	40 to 50
Water	5 to 15

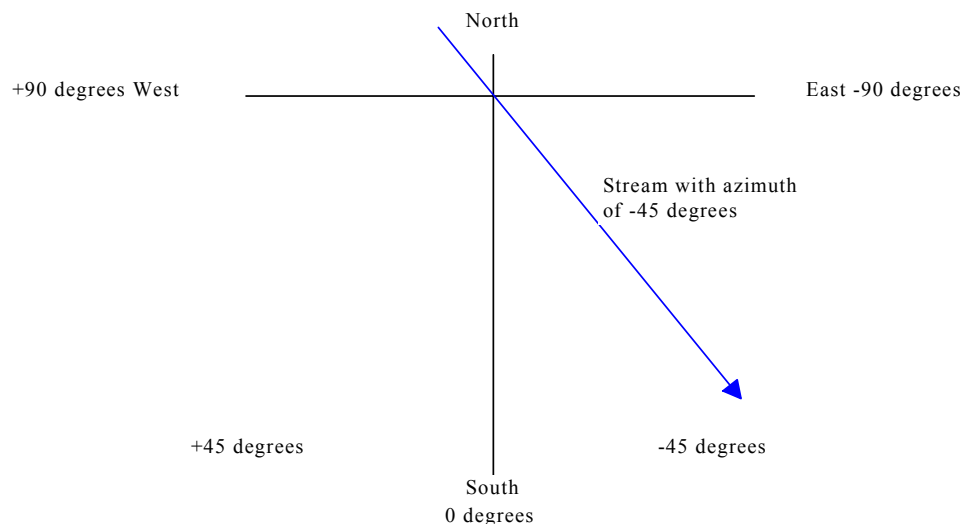
The short wave radiation units are shown in Joules per square meter per second and in Langleys per day. The latter is the common English measurement unit. The values to be carried into **SSTEMP** are the radiation penetrating the water and the daylight hours.

#### Determining Solar Shading (SSSHADE)<sup>4</sup>

To parameterize the model, follow the procedure outlined below:

**Latitude (degrees and minutes)** – Latitude refers to the position of the stream segment on the earth's surface relative to the equator. It may be read from any standard topographic map. Enter both degrees and minutes in the spaces provided.

**Azimuth (degrees)** – Azimuth refers to the general orientation of the stream segment with respect to due South and controls the convention of which side of the stream is East or West. A stream running North-South would have an azimuth of 0°. A stream running Northwest-Southeast would have an azimuth of –45 degrees. The direction of flow does not matter. Refer to the following diagram for guidance:



<sup>4</sup>

US Geological Survey, Biological Resource Division, Midcontinent Ecological Science Center, River Systems Management Section, Fort Collins, CO, 1997. *The Stream Segment and Stream Temperature Models, Version 1.0*, pp. 40-44

Once the azimuth is determined, usually from the topographic map, the East and West sides are fixed by convention.

**Width (feet)** – Refer to the average width of the stream from water's edge to water's edge for the appropriate time of the year. Note that the width and vegetative offset should usually be changed in tandem.

**Month** – Enter the number of the month to be modeled.

**Day** – Enter the number of the day of the month to be modeled. This program's output is for a single day. To compute an average shade value for a longer period (up to one month) use the middle day of that period. The error will usually be less than one percent.

**Topographic Altitude (degrees)** – This is a measure of the average incline to the horizon from the middle of the stream. Enter a value for both East and West sides. The altitude may be measured with a clinometer or estimated from topographic maps. In hilly country, topographic maps may suffice.

**Vegetative Height (feet)** – This is the average height for the shade-producing level of vegetation measured from the water's surface.

**Vegetation Crown (feet)** – This is the average maximum crown diameter for the shade-producing level of vegetation along the stream.

**Vegetation Offset (feet)** – This is the average offset of the stems of the shade-producing level of vegetation from the water's edge.

**Vegetation Density (percent)** – This is the average screening factor (0 to 100%) of the shade-producing level of vegetation along the stream. It is composed of two parts: the continuity of the vegetative coverage along the stream (quantity), and the percent of light filtered by the vegetation's leaves and trunks (quality).

For example, if there is vegetation along 25% of the stream and the average density of that coverage is 85%, the total vegetative density is .25 times .85, which equals .2125, or 21.25%. The value should always be between 0 and 100%.

To give examples of shade quality, an open pine stand provides about 65% light filtering; a closed pine stand provides about 75% light removal; relatively dense willow or deciduous stands remove about 85% of the light; a tight spruce/fir stand provides about 95% light removal. Areas of extensive, dense emergent vegetation should be considered 90% efficient for the surface area covered.

The program will predict the total segment shading for the set of variables provided. The program will also display how much of the total shade is a result of topography and how much is a result of vegetation. The topographic shade and vegetative shade are added to provide total shade. However, one should think of topographic shade as always being dominant in the sense that topography always intercepts radiation first, then the vegetation intercepts what is left. It is total segment shade that is carried forward into the **SSTEMP** program.

## Determine Resulting Stream Temperatures (SSTEMP)<sup>5</sup>

To parameterize the model, follow the procedure outlined below:

**Segment Inflow (cfs or cms)** – Enter the mean daily flow at the top of the stream segment. If the segment begins at a true headwater, the flow may be entered as zero; all accumulated flow will accrue from lateral (groundwater) inflow. If the segment begins at a reservoir, the flow will be outflow from the reservoir. The model assumes steady-state flow conditions.

**Inflow Temperature (°F or °C)** – Enter the mean daily water temperature at the top of the segment. If the segment begins at a true headwater, you may enter any water temperature because zero flow has zero heat. If there is a reservoir at the inflow, use the reservoir release temperature. Otherwise, use the outflow temperature from the upstream segment.

**Segment Outflow (cfs or cms)** – The program calculates the lateral discharge by knowing the flow at the head and tail of the segment, subtracting to obtain the net difference, and dividing by segment length. The program assumes that lateral inflow (or outflow) is uniformly apportioned through the length of the segment. If any “major” tributaries enter the segment, divide the segment into subsections between such tributaries. “Major” is defined as any stream contributing greater than 10% of the mainstem flow.

**Lateral Temperature (°F or °C)** – The temperature of the lateral inflow, barring tributaries, should be the same as the groundwater temperature. In turn, groundwater temperature is often very close to the mean annual air temperature. This can be verified by checking USGS well log temperatures. Obvious exceptions may arise in areas of geothermal activity.

If irrigation return flows make up most of the lateral flow, they may be warmer than mean annual air temperature. Return flow temperature may be approximated by equilibrium temperatures.

**Segment Length (miles or kilometers)** – Enter the length of the segment for which you want to predict the outflow temperature.

**Manning’s n (dimensionless)** – Manning’s n is an empirical measure of the stream’s “roughness.” A generally acceptable default value is 0.035. The variable is necessary only if you are interested in predicting the minimum and maximum daily fluctuation in temperatures. This variable is not used in the prediction of the mean daily water temperature, and the model is not particularly sensitive to it.

**Elevation Upstream (feet or meters)** – Enter the elevation as taken from a 7-1/2 minute quadrangle map.

**Elevation Downstream (feet or meters)** – Enter the elevation as taken from a 7-1/2 minute quadrangle topographic map.

**Width’s A Term (dimensionless)** – This variable may be derived by calculating the wetted width versus discharge relationship. To conceptualize this, plot the width of the segment on the Y-axis and discharge on the X-axis. Three or more measurements are

<sup>5</sup>

US Geological Survey, Biological Resource Division, Midcontinent Ecological Science Center, River Systems Management Section, Fort Collins, CO, 1997. *The Stream Segment and Stream Temperature Models, Version 1.0*, pp. 44-49

much better than two. The relationship should approximate a straight line, the slope of which is the B term.

**Width's B Term (dimensionless)** – The B term is calculated by linear measurements from the above mentioned plot. A good estimate in the absence of anything better is 0.20 (Leopold, 1964).

**Thermal Gradient (Joules/Meter<sup>2</sup>/Second/°C)** – This quantity is a measure of the rate of thermal flux from the streambed to the water.

The model is not particularly sensitive to this variable. The default value is 1.65.

**Air Temperature (°F or °C)** – Enter the mean daily air temperature.

This and the following meteorological variables may come from weather reports which can be obtained for a weather station near the site.

**Relative Humidity (percent)** – Obtain the mean daily relative humidity for the area by measurement or from the weather service.

**Wind Speed (miles/hour or meters/second)** – Measure or obtain from the weather service.

**Percent Possible Sun (percent)** – This variable is an indirect measure of cloud cover. Ten percent cloud cover is 90% possible sun. Estimates are available from the weather service or can be directly measured.

**Solar Radiation (Langley's/day or Joules/meter<sup>2</sup>/second)** – Enter the results from the SSSOLAR program. If you use a source other than SSSOLAR (such as Cinquemani, 1978), you should assume that approximately 93% of the ground-level solar radiation actually enters the water; the rest is assumed to be reflected. Thus, multiply any recorded ground-level solar measurements by 0.93 to calculate the radiation actually entering the water.

**Daylight Length (hours)** – Adjust the time between sunrise and sunset for the time of year. You may use the SSSOLAR program to calculate this.

**Segment Shading (percent)** – This variable refers to how much of the segment is shaded by vegetation, cliffs, etc. If 10% of the water surface is shaded, enter 10. To be accurate, the SSSHADE model should be used to predict the actual shading value based on topography, vegetative coverage and vegetative density.

In lieu of using the SSSHADE model, you may think of the shade factor as being the average percent of water surface shaded throughout the day. In actuality, shade represents the percent of the incoming solar radiation that does not reach the water.

**Ground Temperature (°F or °C)** – Use mean annual air temperature from the weather service.

**Dam at Inflow (Yes = 1 No = 0)** – If a reservoir is supplying the inflow, enter a 1, otherwise enter a 0.

The maximum daily water temperature is calculated by following a parcel of water from solar noon at the top of the stream segment to the end of the segment, allowing it to heat up towards the maximum equilibrium temperature. If there is an upstream reservoir or spring that is the source of constant temperature water, and the distance upstream is less than the distance traveled by the water parcel from solar noon to the end of the segment, the water parcel from the dam's discharge is heated instead of the water parcel a full half day's travel upstream. The stream segments'

meteorology and geometry supplied as variables will apply to the distance upstream through which the water column travels.

The program will predict the 24-hour minimum, mean and maximum daily water temperature for the set of variables provided. The theoretical basis for the model is strongest for the mean daily temperature. The maximum daily temperature varies as a function of several different factors. The mean daily equilibrium temperature is that temperature which the mean daily water temperature will approach if all conditions remain the same as the water parcel travels downstream. Of course, all conditions cannot remain the same, since the elevation changes immediately.

The maximum daily equilibrium temperature is that temperature which the maximum daily water temperature will approach.

Other results include the intermediate variables, average width, average depth and slope, calculated from the twenty input variables, and the heat flux components. These heat flux components are abbreviated in the program's output as follows:

ATM	=	atmospheric component
CVN	=	convection component
CDN	=	conduction component
EVP	=	evaporation component
FRC	=	friction component
SOL	=	solar radiation component
VEG	=	vegetative radiation component
WAT	=	water's back radiation component

### Assumptions and Limitations<sup>6</sup>

There are several assumptions that apply to SSTEMP. These assumptions in turn dictate the limitations in terms of model applications.

First, SSTEMP is a steady state model. It assumes that the conditions being simulated involve only steady flow – no hydropeaking can be simulated unless the flows are essentially constant for the entire averaging period. The minimum average period is one day. Similarly, the boundary conditions of SSTEMP are assumed homogeneous and constant. This has implications for the maximum size of the network simulated for a single averaging period.

Second, SSTEMP assumes homogeneous and instantaneous mixing wherever two sources of water are combined. There is no lateral or vertical temperature distribution (or dispersion/diffusion), represented in the model.

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<sup>6</sup> US Geological Survey, Biological Resource Division, Midcontinent Ecological Science Center, River Systems Management Section, Fort Collins, CO, 1997. *The Stream Segment and Stream Temperature Models, Version 1.0*, pp. 26-27

Third, SSTEMP itself is meant solely for stream temperature predictions. It will not handle stratified reservoirs, though river-run reservoirs with equilibrium releases may be simulated.

Fourth, SSTEMP is not a hydrology model. It should be relied on to distribute flows in an ungaged network. That is often an additional, non-temperature model task.

Fifth, SSTEMP may not be reliable in very cold conditions, i.e., water temperatures less than 4°C. It is not meant for ice or the like.

Finally, SSTEMP have been tested only in the northern hemisphere.

### **Temperature Allocations as Determined by Percent (%) Shade**

Tables 12-1 through 12-9 show output of the three-month model runs from July-September 1998. As the % total shade is increased, the mean 24-hour temperature decreases until the HQCWF standard (20°C, 68°F) is achieved for each stream segment requiring a temperature TMDL. On Redondo Creek, this occurs when the % total shade is 25% and higher. The load allocation (LA) of 242 joules/meter<sup>2</sup>/second is achieved at 33% shade or higher, according to the model runs. Similarly on San Antonio Creek, the standard is achieved on the lower, middle and upper segments when the % total shade is 26, 24, and 24 percent (and higher), respectively. The load allocations of 238, 247, and 245 joules/meter<sup>2</sup>/second are achieved at 34% shade, 31% shade, and 32% shade (or higher), respectively, according to the model runs. A summary of this information for each segment requiring a TMDL is found on Tables 12-1 through 12-9. Detailed output for each run on each stream reach is located in Appendix D at the end of this document.

### **LINK BETWEEN WATER QUALITY AND POLLUTANT SOURCES**

Decreased effective shade levels result from reduction of riparian vegetation. This leads to increased incident solar radiation on the water surface and therefore increased energy loading. Wider stream channels also increase the stream surface area exposed to sunlight and heat transfer. Riparian area and channel morphology disturbances are attributed to past and to some extent current rangeland grazing practices which have resulted in reduction of riparian vegetation and streambank destabilization. These nonpoint sources of pollution primarily affect the water temperature through increased solar loading by: (1) increasing stream surface solar radiation and (2) increasing stream surface area exposed to solar radiation (Figure 12-2).

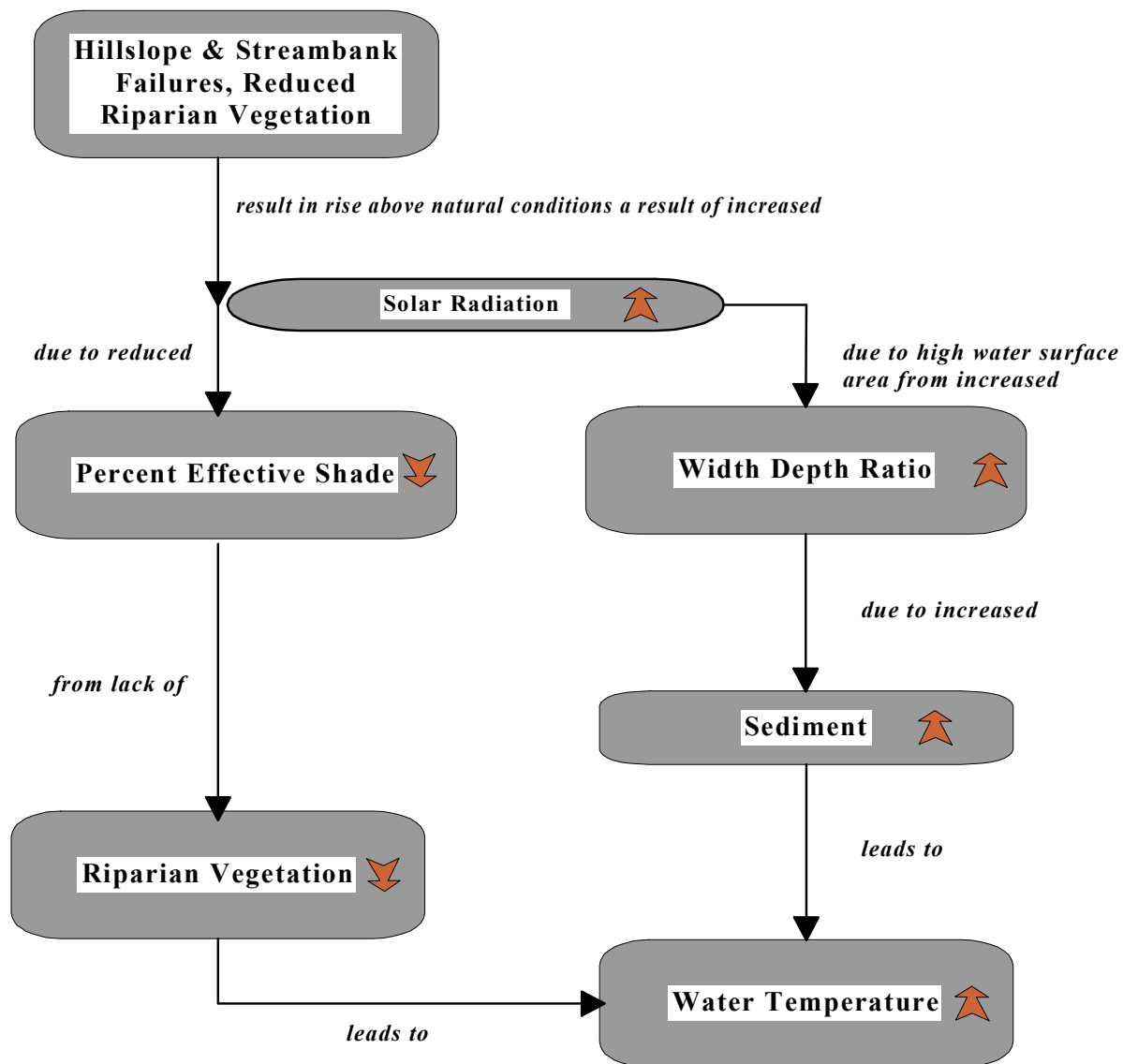
Riparian vegetation, stream morphology, hydrology, climate and geographic location and aspect influence stream temperature. Although climate and geographic location and aspect are outside of human control, the condition of the riparian area, channel morphology and hydrology can be affected by land use activities. Specifically, the elevated summertime stream temperatures attributable to anthropogenic causes in the Jemez Watershed result from the following conditions:

1. Channel widening (increased width to depth ratios) increases the stream surface area exposed to incident solar radiation,
2. Riparian vegetation disturbance reduces stream surface shading, riparian vegetation height and density,

3. Reduced summertime base flows that result from instream withdrawals.

Analysis presented in these TMDLs demonstrate that defined loading capacities will ensure attainment of State water quality standards. Specifically, the relationship between shade, solar radiation, and water quality attainment will be demonstrated. Vegetation density increases will provide necessary shading, as well as encourage bank building processes in severe hydrologic events.

**FIGURE 12-2 FACTORS THAT IMPACT WATER TEMPERATURE**



## **MARGIN OF SAFETY (MOS)**

The Federal Clean Water Act (CWA) requires that each TMDL be calculated with a margin of safety (MOS). This statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS may be expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

The MOS may be implicit, utilizing conservative assumptions for calculation of the loading capacity, WLAs and LAs. The MOS may also be explicitly stated as an added separate quantity in the TMDL calculation.

***In the development of this temperature TMDL, the following conservative assumptions were used to parameterize the model:***

- Warmest time of the year was used in the modeling due to the seasonality of temperature exceedances (April through August)
- The average 1998 monthly ambient air temperatures for June, July and August
- A thermograph was deployed to document the mean daily water temperature near the project site
- Critical upstream and downstream low flows were used due to the decreased assimilative capacity of the stream to absorb and disperse solar heat at these flows
- Low flow was modeled using two formulas developed by the USGS. One formula (Waltemeyer, 1987) is recommended when the ratio between the two watershed areas is between 0.5 and 1.5. The other formula, to be used when the watershed ratio is outside this range, is a regression formula also developed by the USGS (Borland, 1970)
- Stream channel geomorphology was used to determine the level of functionality of the stream along with other physical field measurements that were used in the modeling process
- Elevation and latitude/longitude were determined from available USGS mapping
- Different shading scenarios were used to determine the required decrease in water temperatures at the critical low flow (see tables)
- Analysis results are expressed in ranges
- Analysis results provide a range of temperature outputs (see tables)

Because of the high quality of data and information that was put into this model and the continuous field monitoring data used to verify these model outputs, an explicit MOS of 10% is assigned to this TMDL.

#### *Redondo Creek*

A thermograph was deployed at Station 11 on Redondo Creek on July 15 and retrieved September 28, 1998. Of the 1,796 temperature readings made during this period, 82 measurements exceeded the numeric standard of 20°C. A graphical representation as well as summary chart of the temperature data is included in Appendix E.

#### *San Antonio Creek*

Station 9 on San Antonio Creek included a thermograph that was deployed on July 15 and retrieved September 28, 1998. A total of 1,797 temperature readings were made, varying between 11.5 and 22.5°C. The average temperature was 16.6°C and 84 measurements exceeded the numeric temperature criterion of 20°C.

Station 10, also on San Antonio Creek, included a thermograph that was deployed in mid-July. A total of 1,797 temperature readings were made, varying between 7.5°C and 24.5°C. The average temperature was 16.1°C and 117 measurements exceeded the numeric temperature criterion of 20°C. A graphical representation as well as summary chart of the temperature data is included in Appendix E.

#### *Rio Cebolla (2)*

A thermograph was deployed near Station 16, close to Seven Springs Campground on Rio Cebolla, on July 24 and retrieved September 28, 1998. Of the 1,587 temperature readings made during this period, 54 measurements exceeded the numeric standard of 20°C. The temperature readings varied from 6.5 to 22.5°C and the average of all temperatures was 14.4°C. A graphical representation as well as a summary chart of the temperature readings can be found in Appendix E.

#### *Rio de las Vacas*

A total of three thermographs were located on Rio de las Vacas. The first was deployed at Station 18 on July 16 and retrieved September 29, 1998. A total of 1,795 temperature readings were made during this period and the readings varied from 6.0 to 24.5°C. The average of all temperatures was 15.5°C and 218 measurements exceeded the numeric standard of 20°C.

The second thermograph at Station 19, was deployed in July and a total of 1,793 temperature readings were recorded. The average of all temperatures was 17.0°C, they varied from 7.0 to 27.0°C, and 375 measurements exceeded the numeric temperature criterion of 20°C.

The third was located at Station 23 at State Highway 126. Of the 1,792 readings taken, temperatures varied from 7.0 to 21.0°C, they averaged 13.4°C and only 3 measurements exceeded the numeric temperature criterion of 20°C. Graphical representations and summary charts for each of the locations on Rio de Las Vacas can be found in Appendix E.

Over the years, reduced riparian vegetation, including herbaceous woody plants such as willow, narrowleaf cottonwoods or alder along the stream, and exceedances in temperature standards have been seen and documented in Rio de las Vacas.

As previously mentioned, the current New Mexico 2000-2002 §303(d) list shows the Rio de las Vacas from the confluence with the Rio Cebolla to Rito de las Palomas (14 miles) listed as not supporting its designated use due to temperature exceedances. Prior to this most recent list of impaired waters in New Mexico, the 1998-2000 §303(d) list similarly showed the Rio de las Vacas exceeding temperature standards. Because of the previous listing, the document titled, *Total Maximum Daily Load For Temperature on the Middle Rio de Las Vacas* was drafted in October, 1999. This TMDL addressed only two out of the 14 miles and can be found on the website [www.nmenv.state.nm.us](http://www.nmenv.state.nm.us). Portions of that document were incorporated into this one.

#### *Rito Peñas Negras*

A thermograph was deployed on the upper reach of the Rito Peñas Negras and only 9 readings, out of a total of 1,847, exceeded the numeric standard of 20°C.

A second thermograph was deployed on Rito Peñas Negras at Station 21, and 80 readings, out of a total of 1,791, exceeded the numeric standard of 20°C.

The lower portion of the Rito Peñas Negras included a thermograph at Station 20 deployed on July 15 and retrieved September 28, 1998. A total of 117 measurements, out of 1,793 readings, exceeded the numeric temperature criterion of 20°C. Graphical representations and summary charts of the temperature data for these three locations on the Rito Peñas Negras can be found in Appendix D.

### **CONSIDERATION OF SEASONAL VARIATION**

Section 303(d)(1) of the CWA requires TMDLs to be “established at a level necessary to implement the applicable water quality standard with seasonal variation.” Both stream temperature and flow vary seasonally and from year to year. Water temperatures are coolest in winter and early spring months.

Thermograph records show that temperatures may exceed State water quality standards in summer and in the case of the stream segments being focused on in the Jemez River Basin, early fall. Warmest stream temperatures corresponded to prolonged solar radiation exposure, warm air temperature and low flow conditions. These conditions occur during late summer and early fall and promote the warmest seasonal instream temperatures.

### **FUTURE GROWTH**

Estimations of future growth are not anticipated to lead to a significant increase for temperature that cannot be controlled with best management practice implementation in this watershed.